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Appenzeller et al.

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(54) **ANCHOR-IN-ANCHOR SYSTEM**

(71) Applicant: **DePuy Synthes Products, Inc.**,
Raynham, MA (US)

(72) Inventors: **Andreas Appenzeller**, Oberdorf (CH);
Daniel Fluri, Oberdorf (CH); **Peter**
Steiger, Herzogenbuechse (CH)

(73) Assignee: **DePuy Synthes Products, Inc.**,
Raynham, MA (US)

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(2013.01); **A61B 17/8695** (2013.01)

(58) **Field of Classification Search**

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See application file for complete search history.

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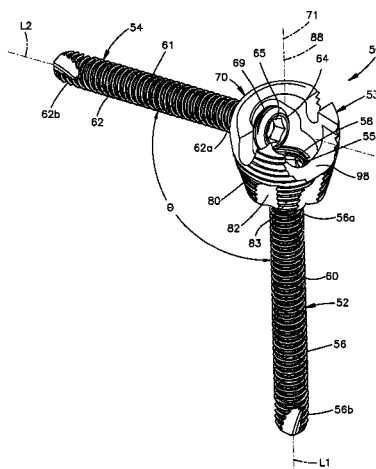
Primary Examiner — Sameh Boles

(74) *Attorney, Agent, or Firm* — Baker & Hostetler LLP

(57) **ABSTRACT**

An anchor-in-anchor fixation system is provided for securing
underlying structure, such as bone. The fixation system
includes a linkage that defines first and second bores, a first
bone anchor having a shaft for fixation to underlying bone,
and a head that is configured to attach to the linkage in the first
bore, and a second bone anchor having a shaft for fixation to
underlying bone and a head that is configured to attach to the
linkage in the second bore.

20 Claims, 15 Drawing Sheets



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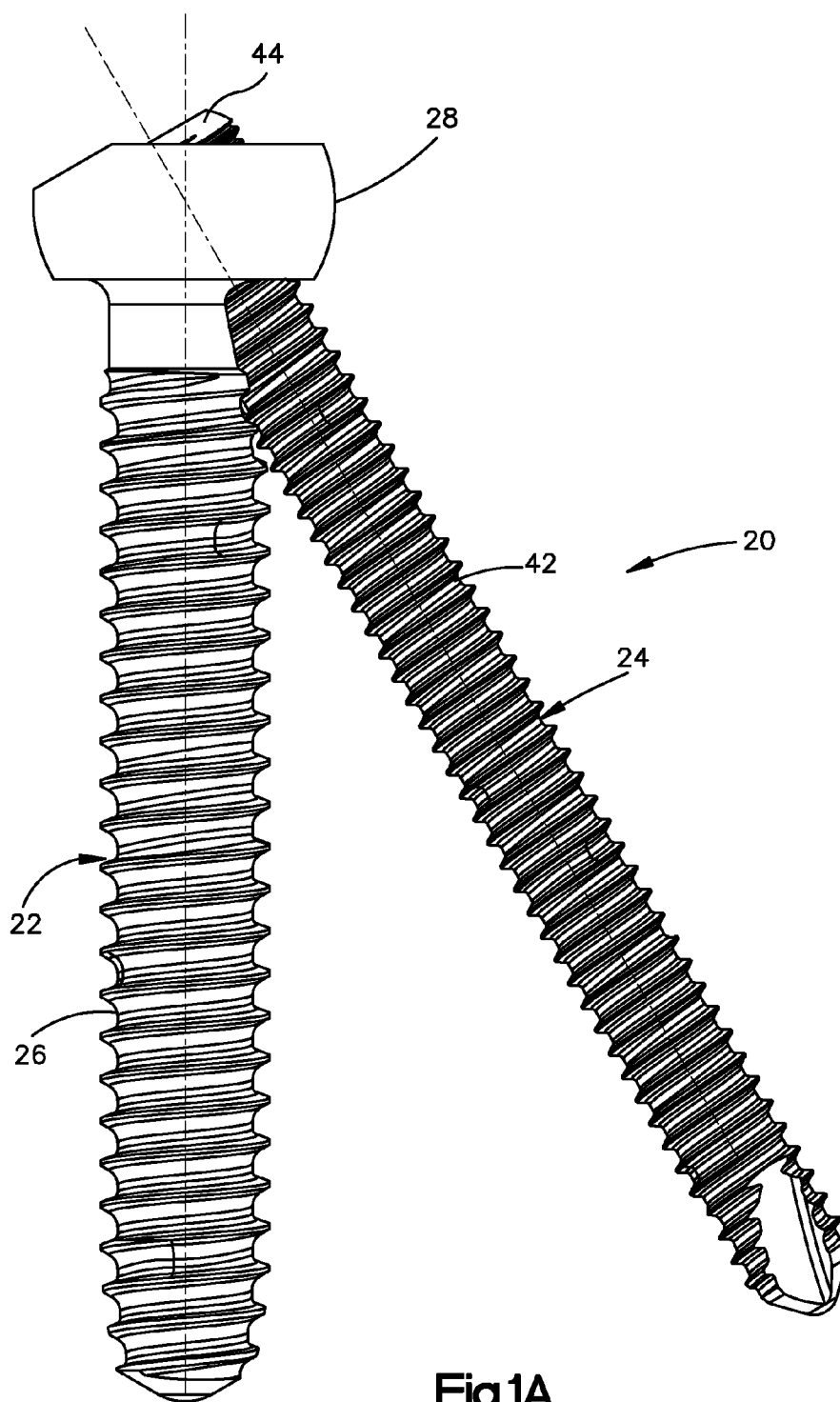


Fig.1A
PRIOR ART

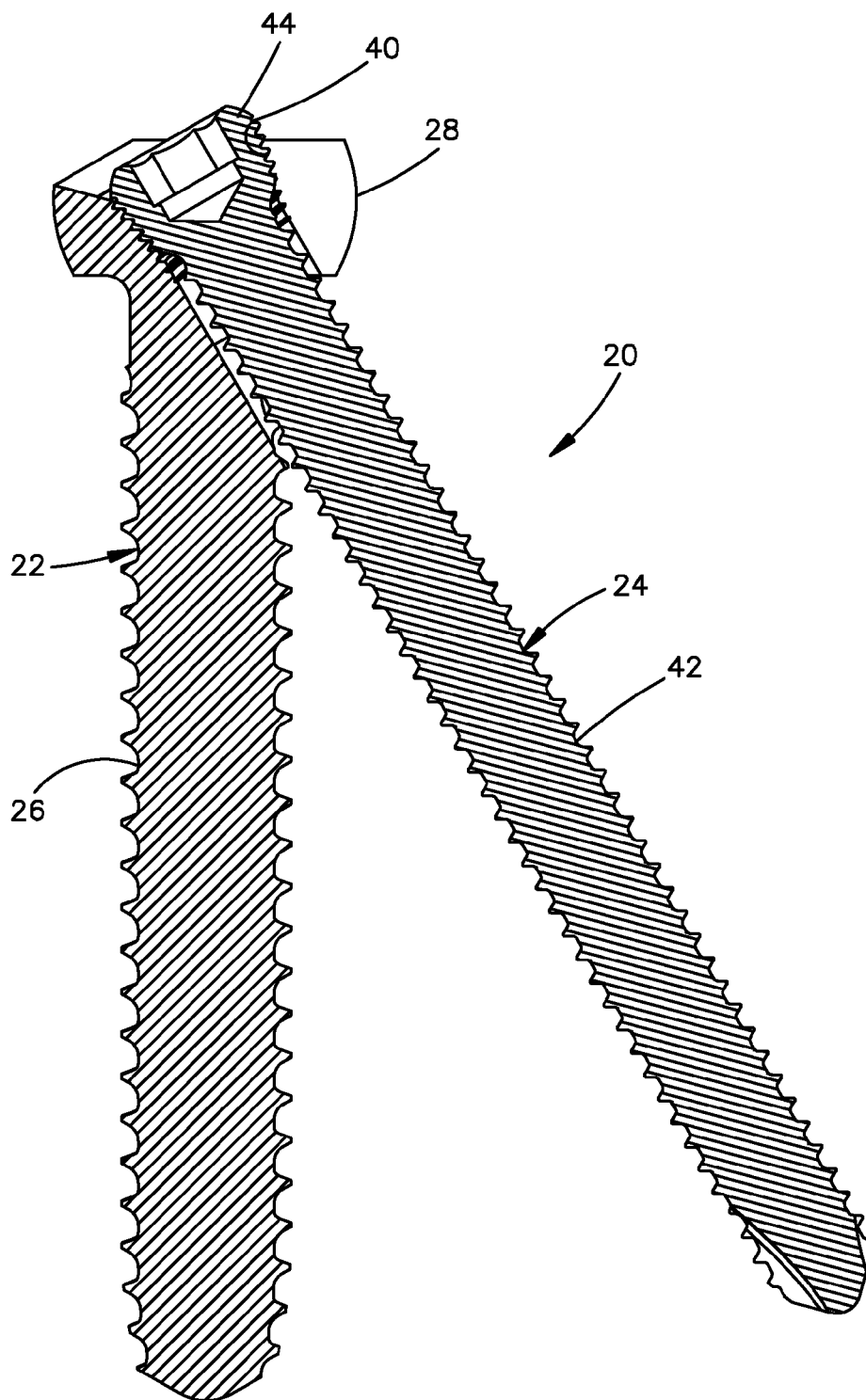


Fig.1B
PRIOR ART

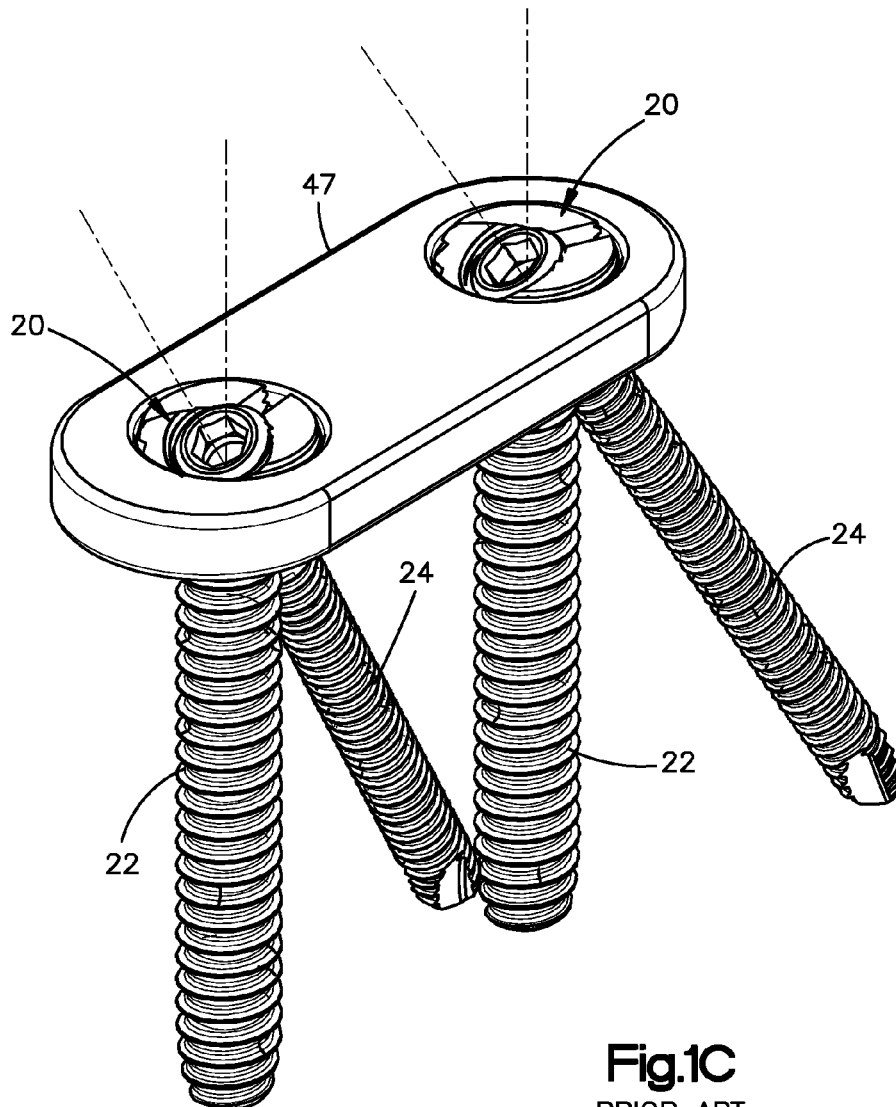


Fig.1C
PRIOR ART

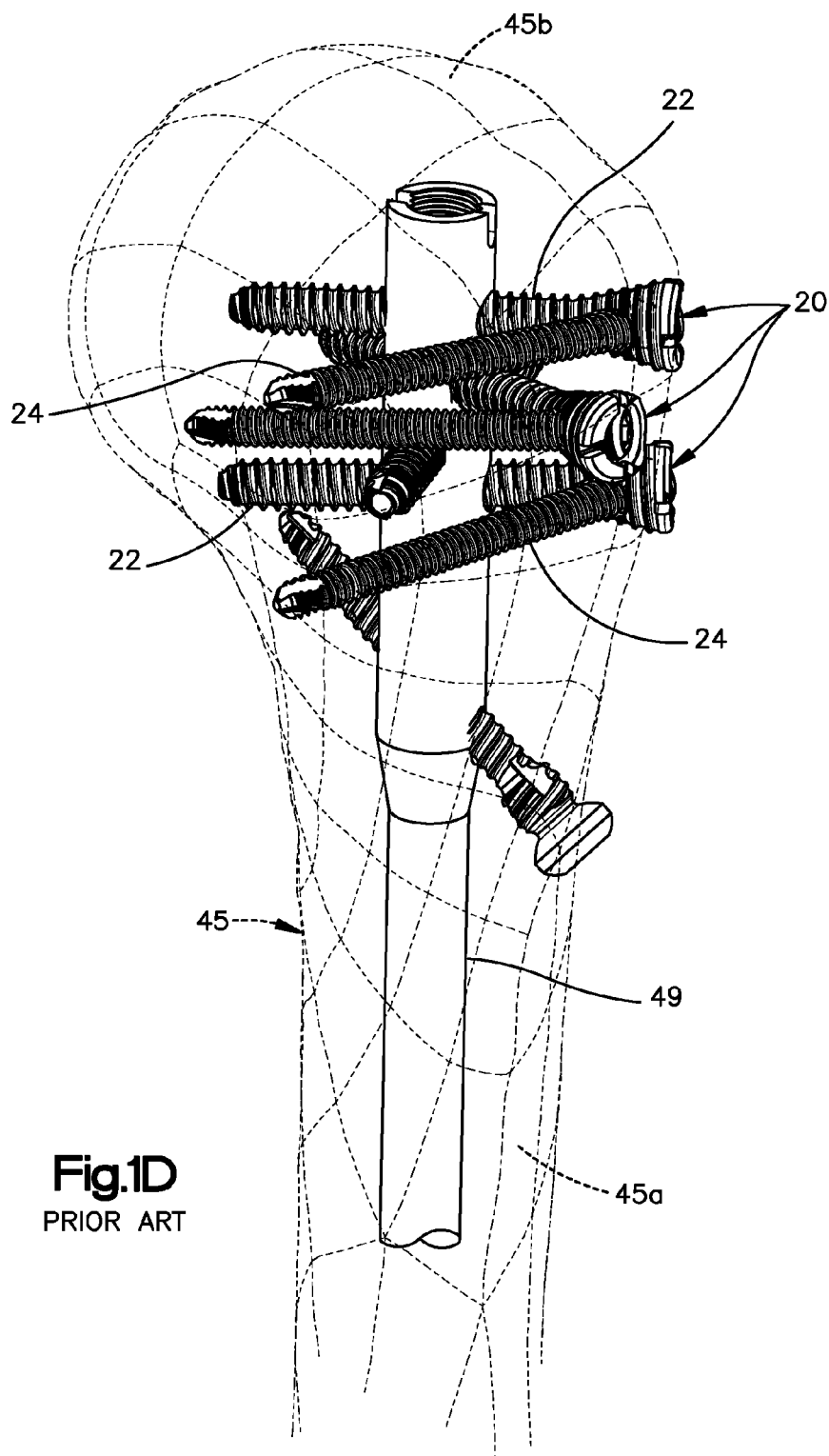


Fig. 1D
PRIOR ART

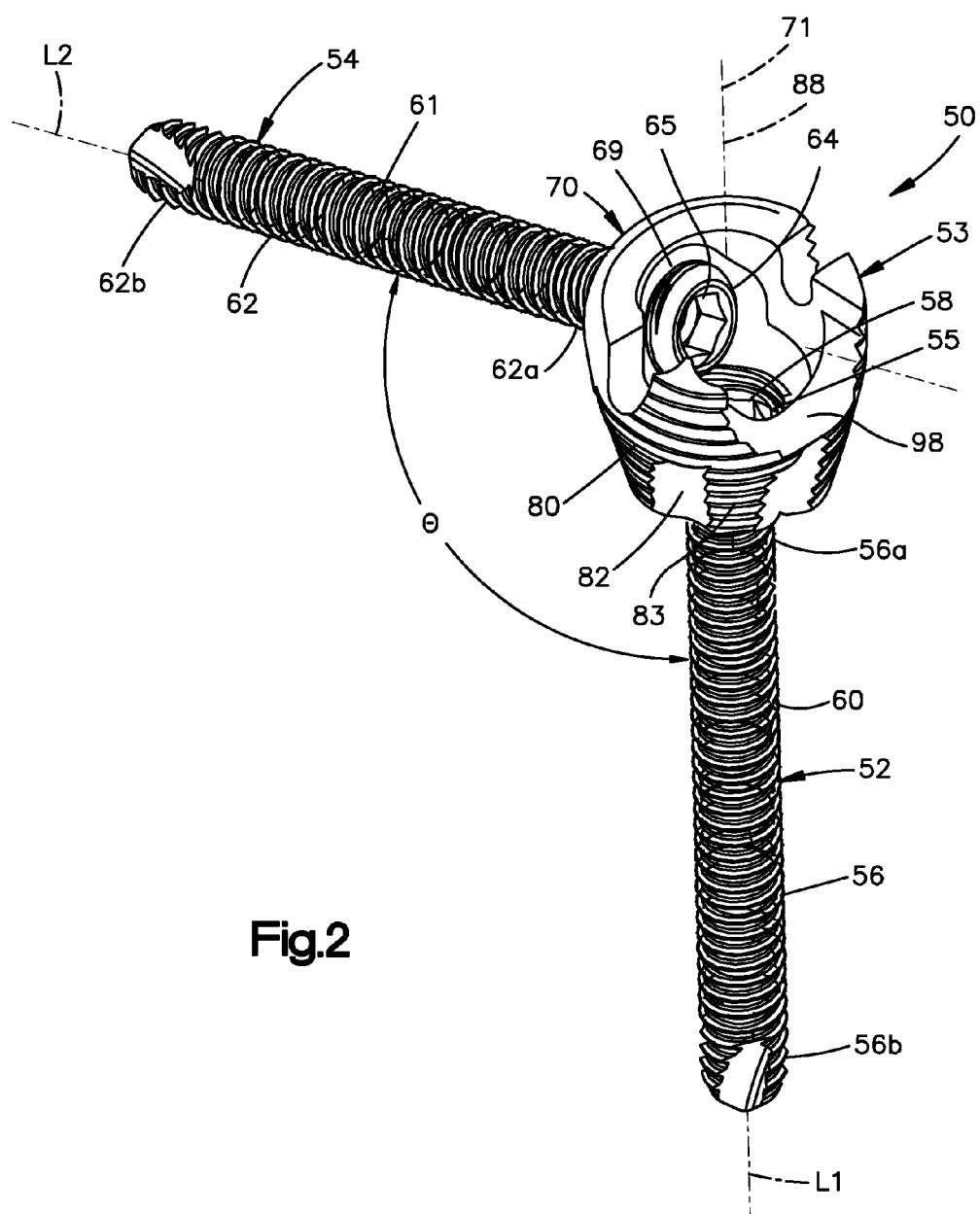
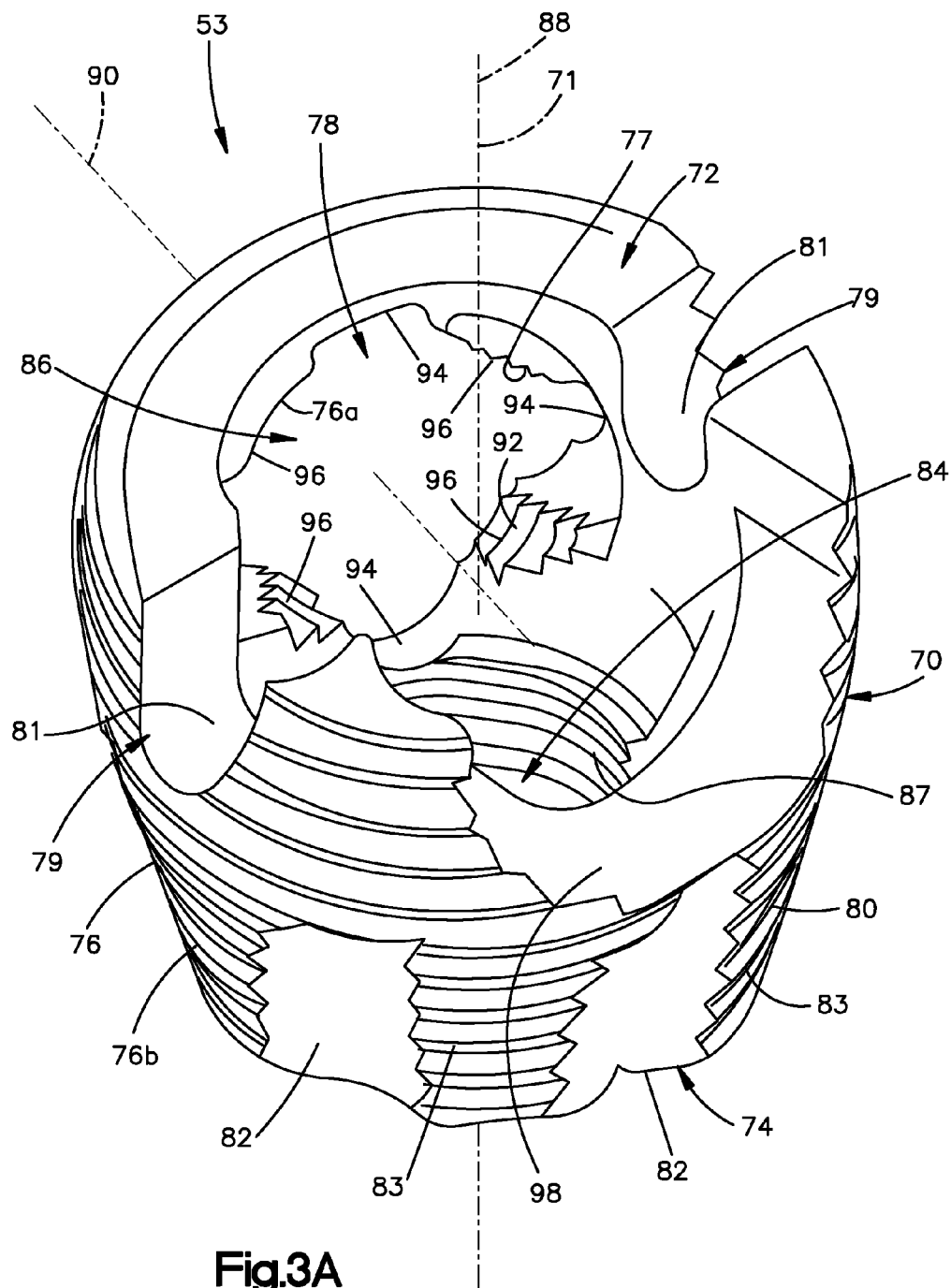


Fig.2



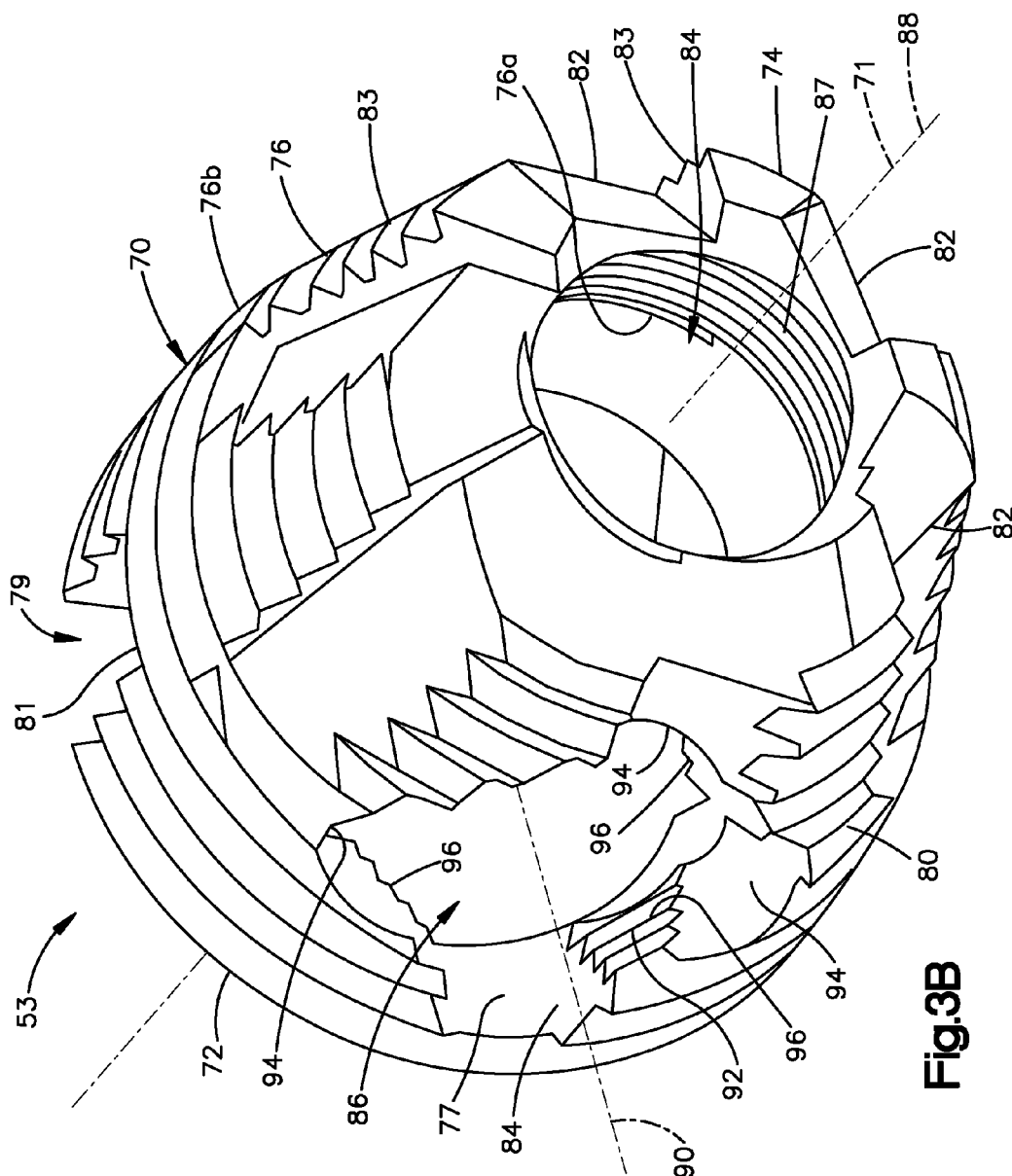


Fig.3B

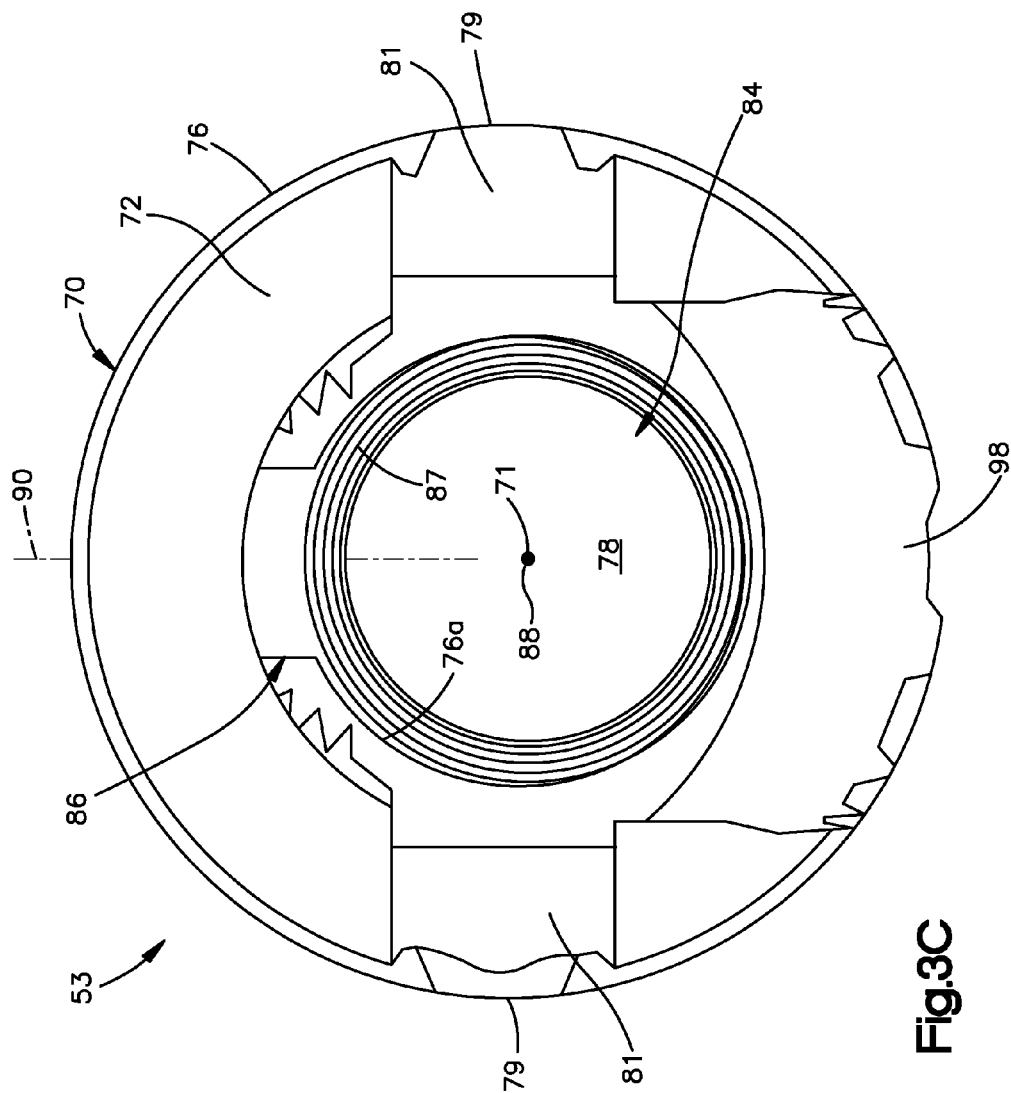
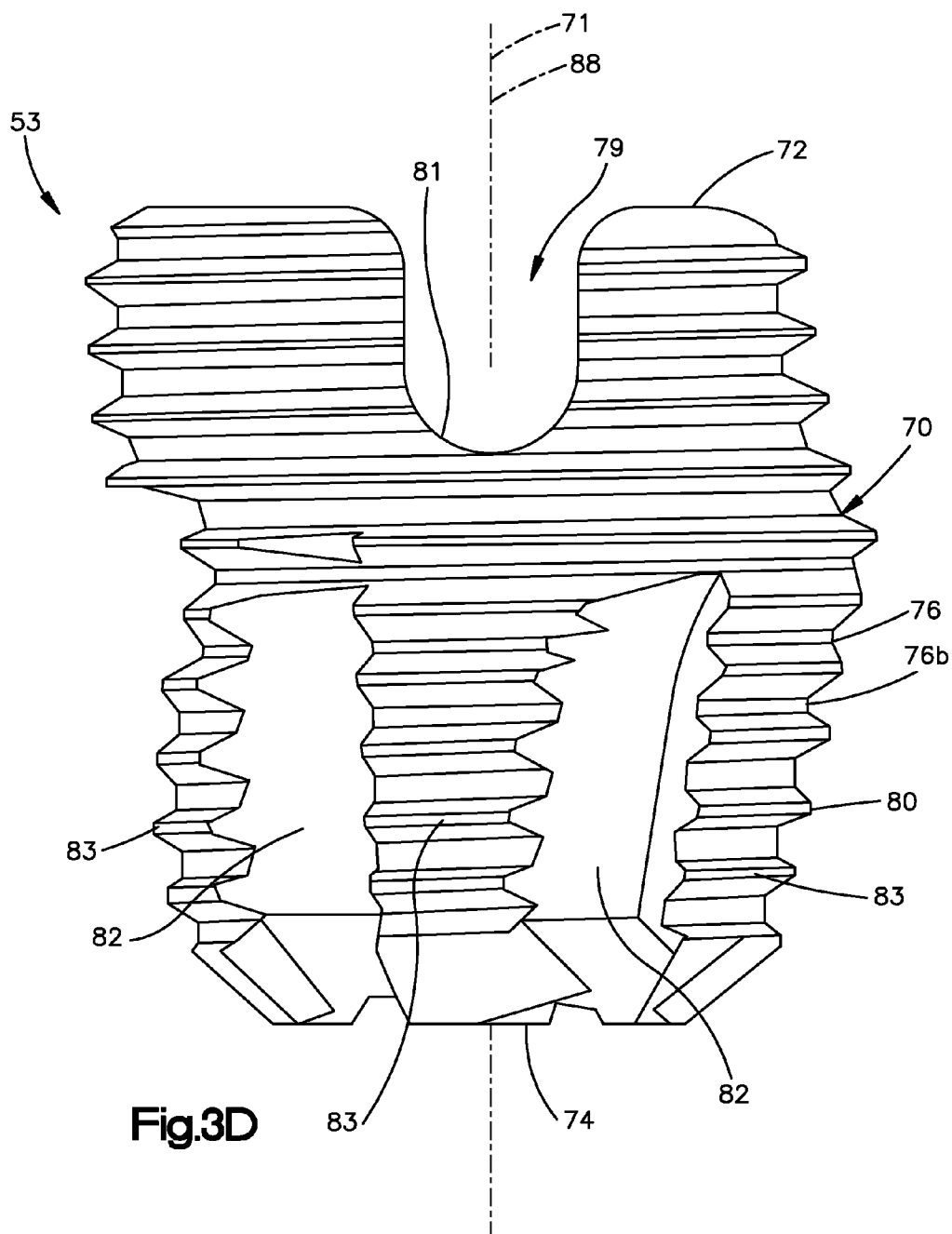


Fig. 3C



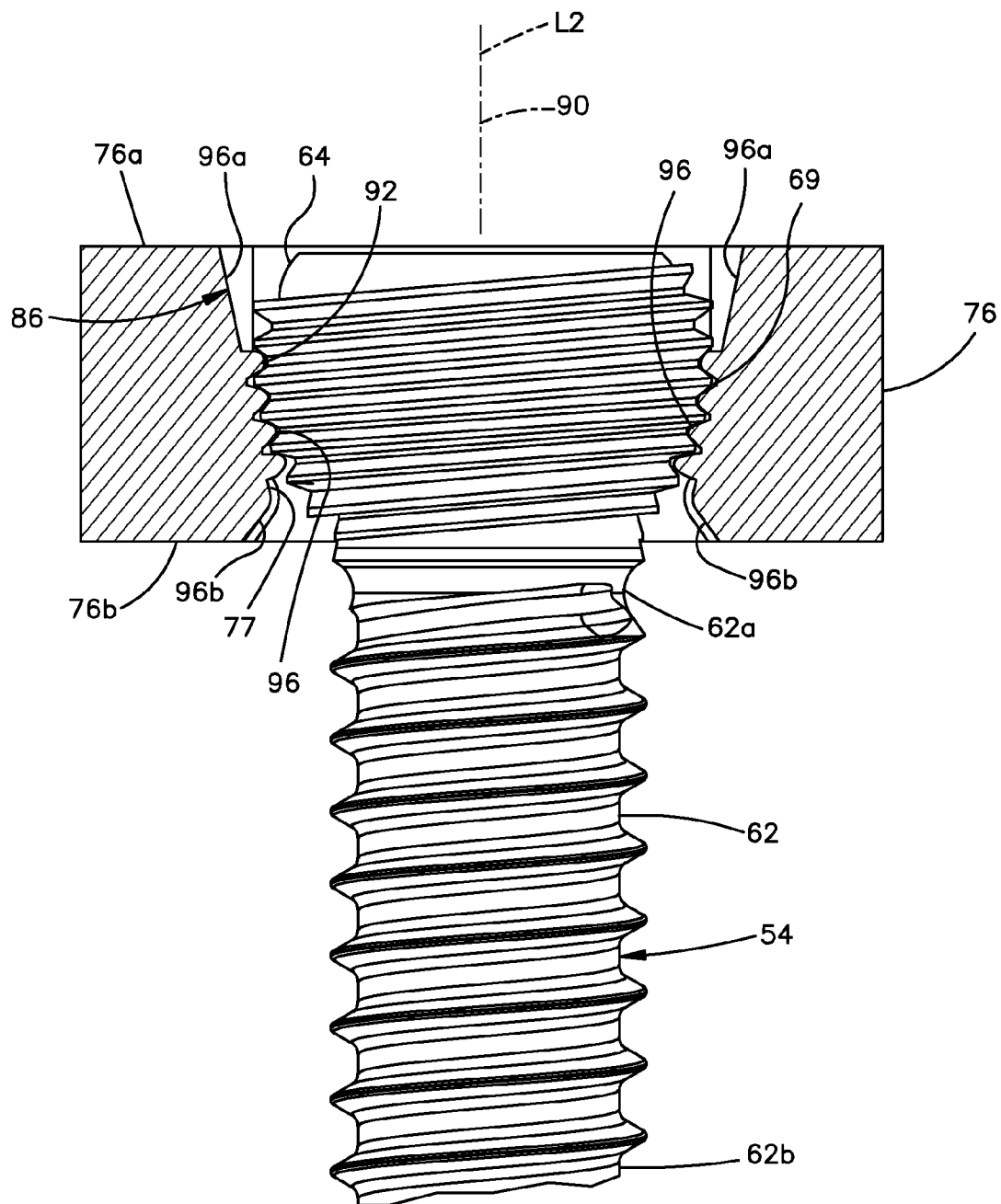


Fig.3E

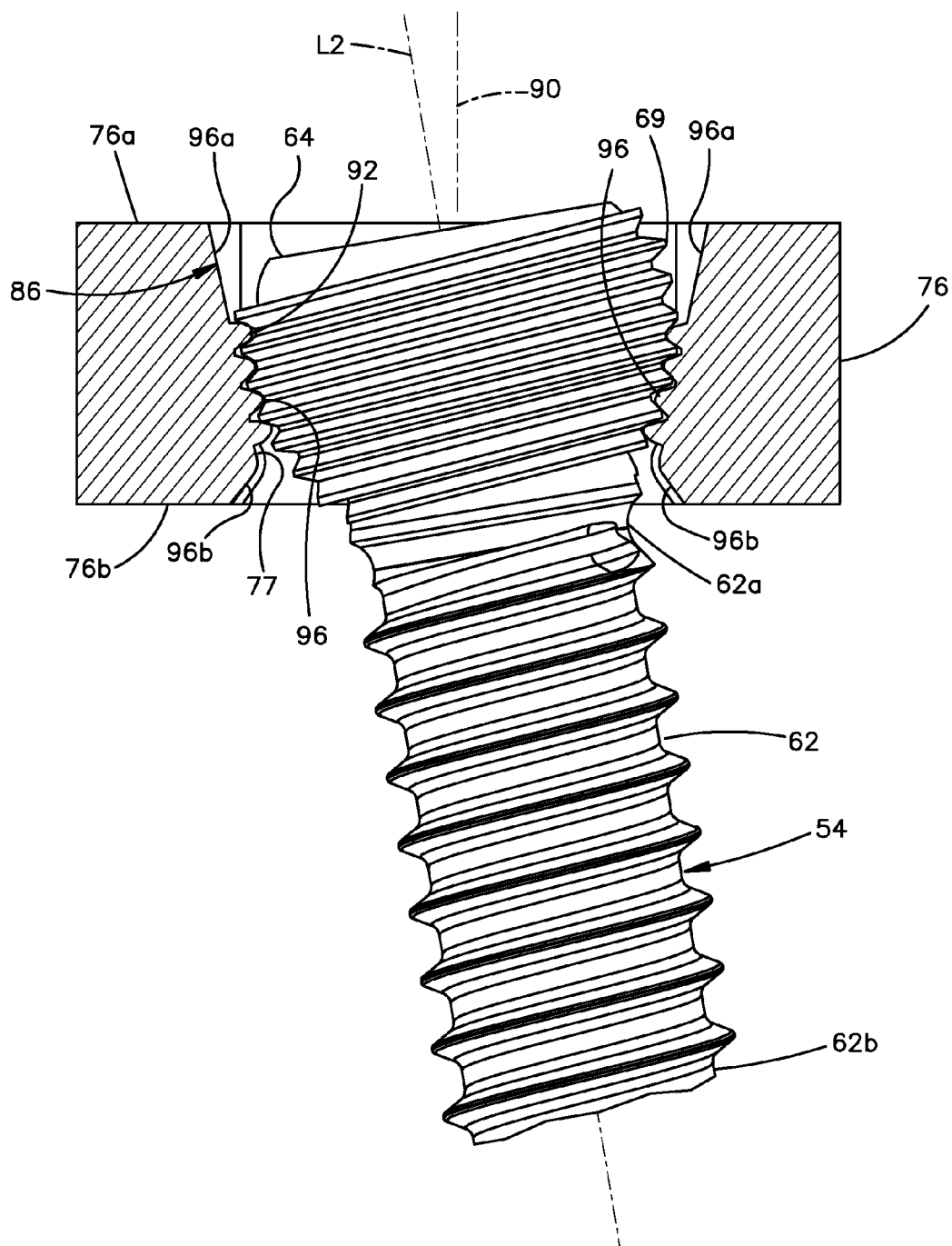


Fig.3F

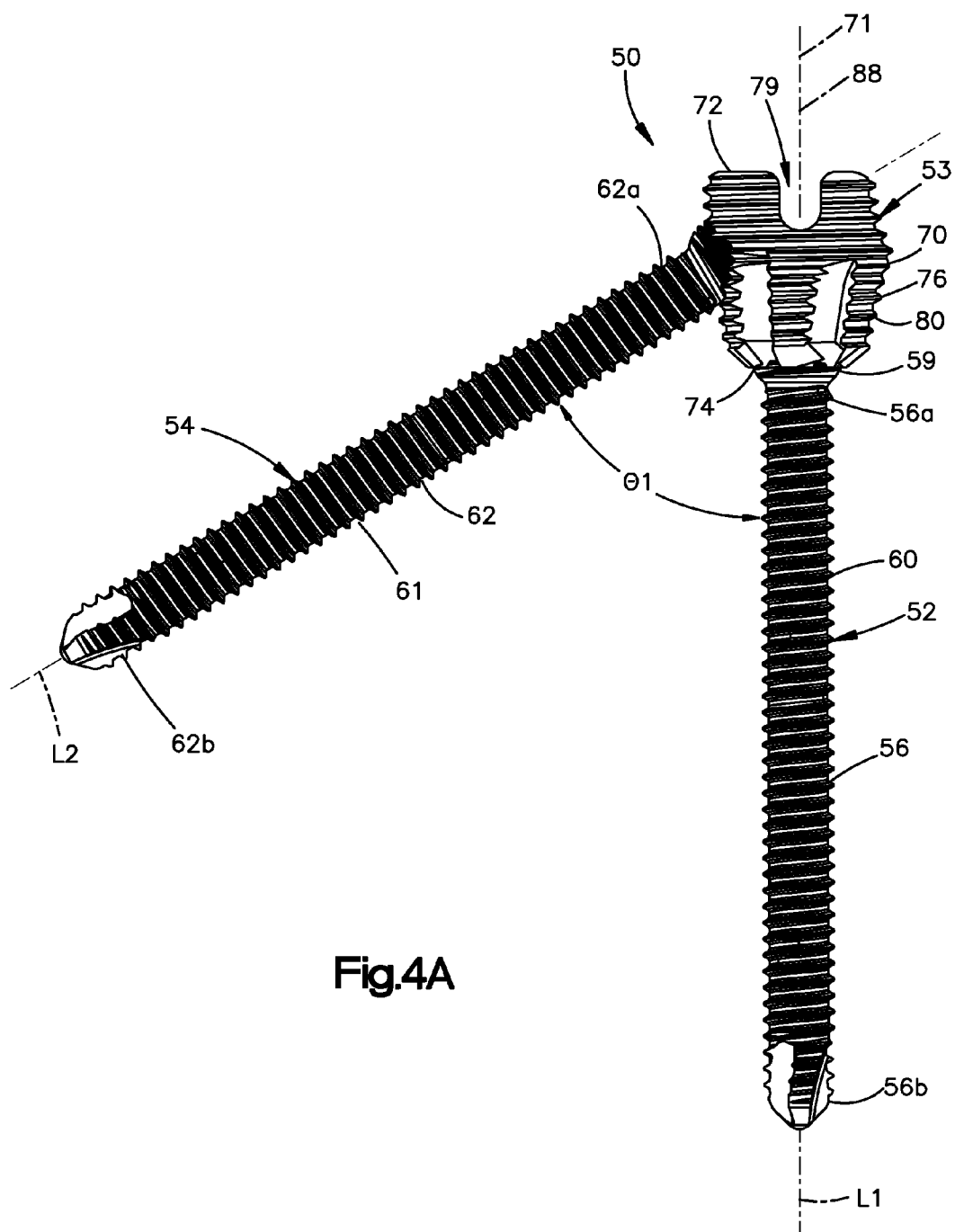
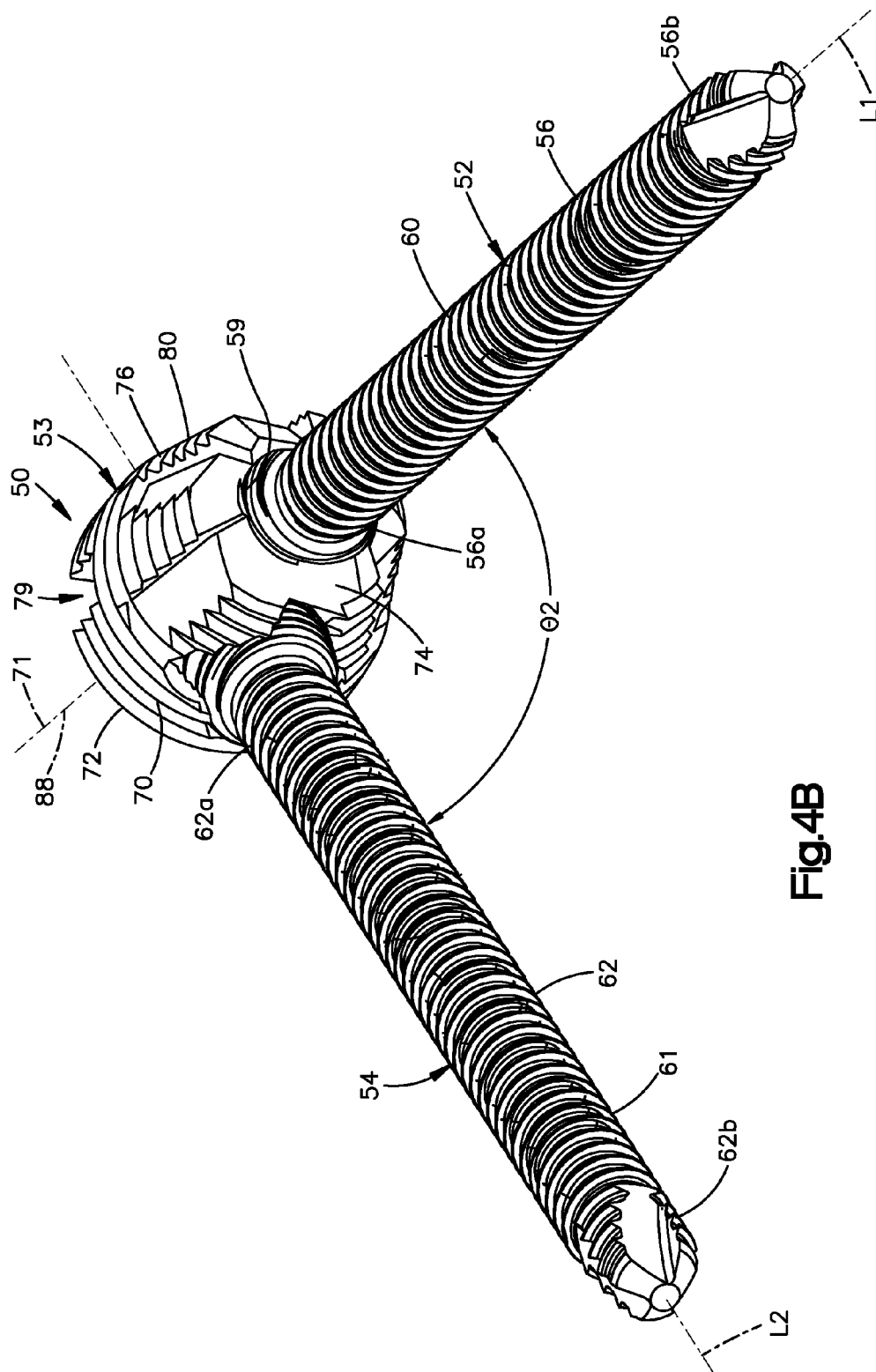


Fig.4A



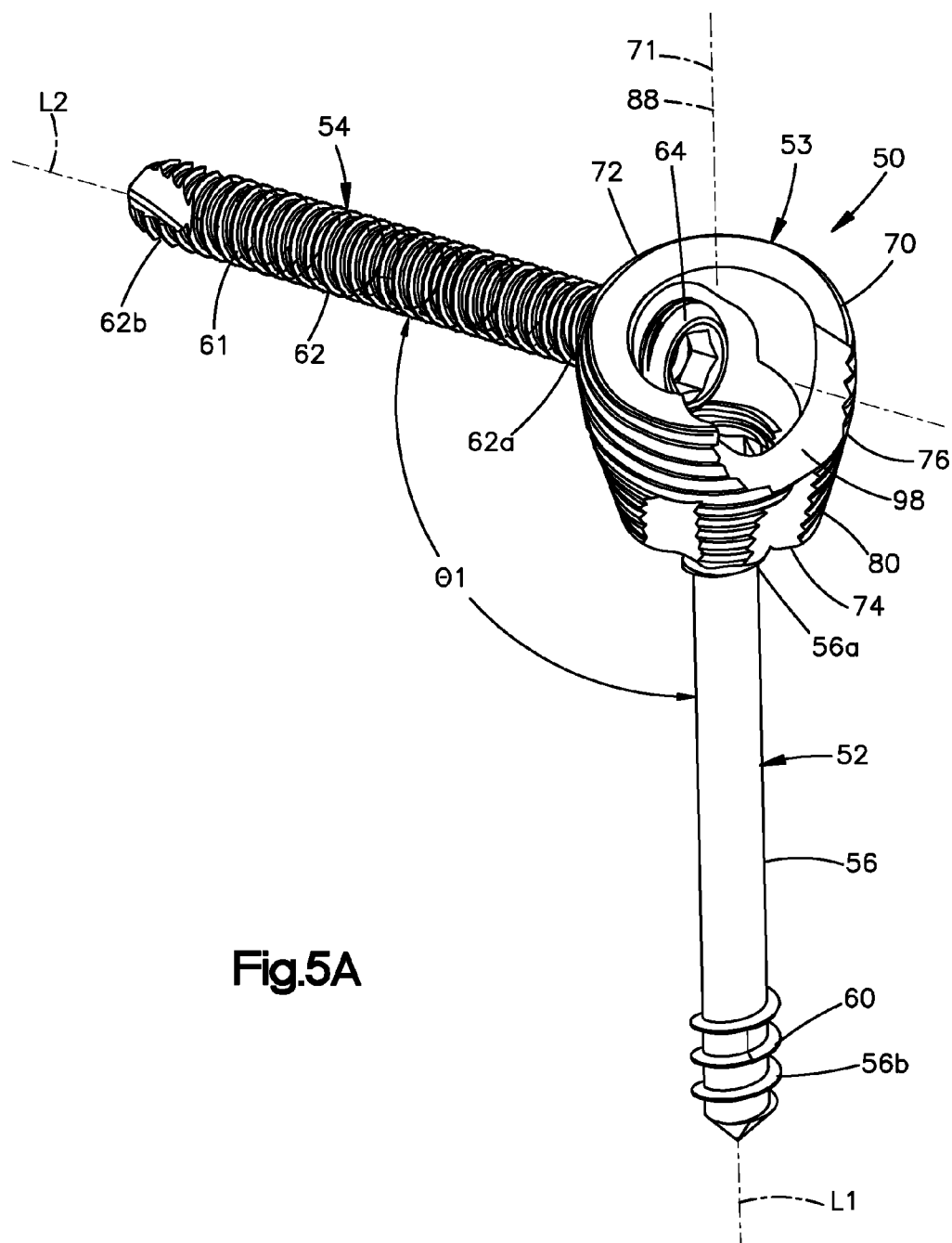


Fig.5A

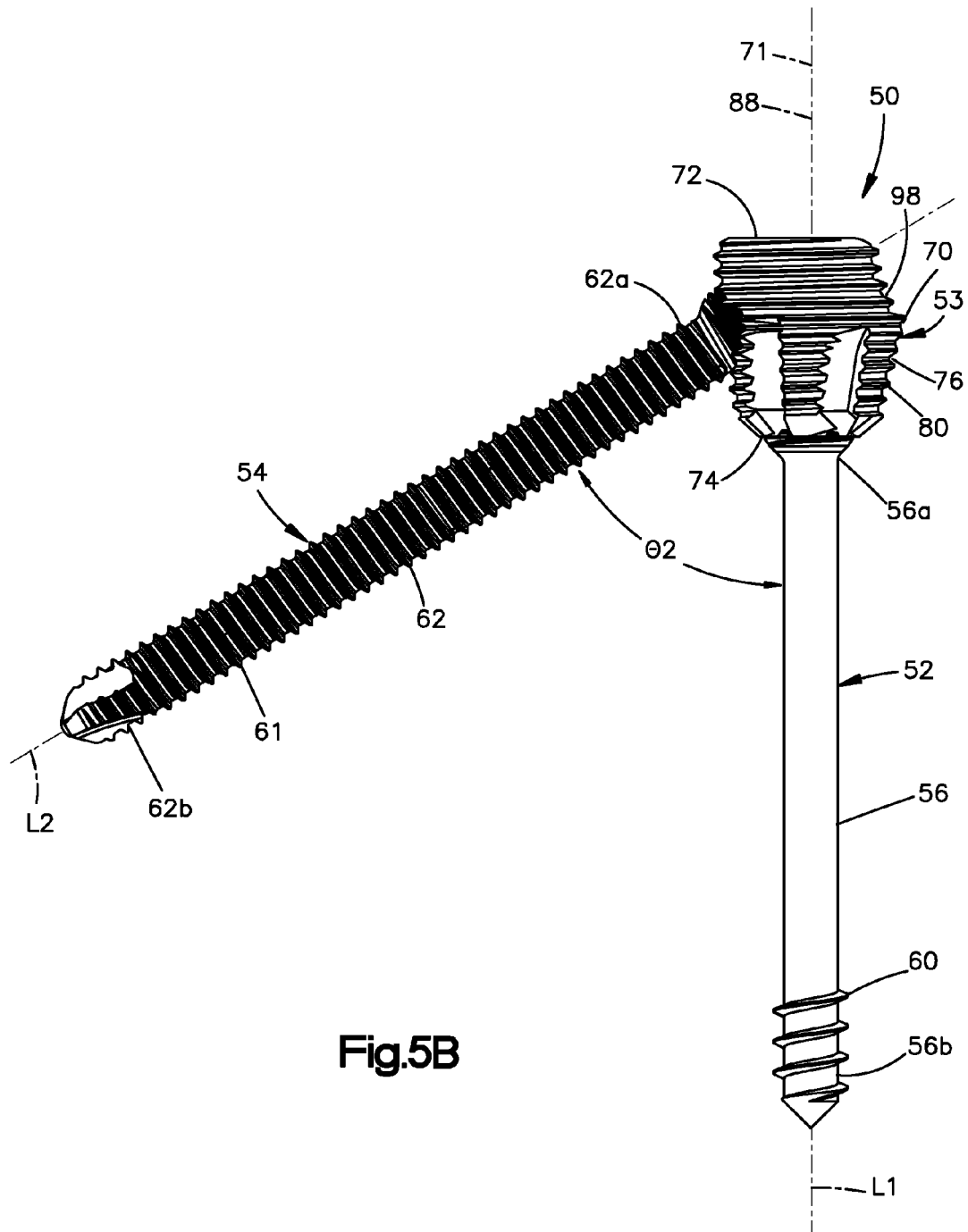


Fig.5B

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ANCHOR-IN-ANCHOR SYSTEM**CROSS-REFERENCE TO RELATED APPLICATIONS**

This claims the benefit of U.S. patent application Ser. No. 61/691,961 filed Aug. 22, 2012, the disclosure of which is hereby incorporated by reference as if set forth in its entirety herein.

TECHNICAL FIELD

The present disclosure relates generally to orthopedics, and in particular relates to fixation systems and associated surgical methods and procedures for using same.

BACKGROUND

A variety of fixation devices for the reduction of bone or bone fragments are well known. For instance, external bone fixation devices, or external fixators, are used to reduce fractures of the long bones in the human body. Internal bone fixation devices, such as bone plates, are also commonly used to reduce bone fractures. Spinal fixation devices including intervertebral implants, spinal rods, and the like, are used to replace intervertebral discs, fuse or align adjacent vertebrae, and address other spinal issues.

A large number of fixation devices are attached to underlying bone using bone anchors, which can include screws, pins, nails, and the like. For instance, a typical bone plate includes screw holes that accommodate bone screws which are drilled into underlying bone on opposing sides of a fracture to join bone segments together. A typical cervical spine implant can likewise include screw holes that accommodate screws which are drilled into adjacent vertebral bodies in order to fix the position of the implant. Unfortunately, the attachment of fixation devices to the underlying bone can become compromised if, for instance, the screw becomes dislodged from the bone during normal anatomical function.

Referring to FIGS. 1A-B, a conventional anchor-in-anchor fixation system **20** includes a first bone anchor **22** that includes a first head **28** and a first shaft **26** that extends from the first head **28** and is integral and monolithic with the first head **28**, and a second bone anchor **24** that includes a second head **44** and a second shaft **42** that extends from the second head **44** and is integral and monolithic with the second head **44**. The first bone anchor **22** defines a bore **40** that extends through the first head **28** along a direction oblique to the first shaft **26**. The bore **40** is sized greater than the second shaft **42**, such that the second shaft **42** passes through the bore **40**. The bore **40** can be threaded, and sized substantially equal to the second head **44**, which can also be threaded, such that the second head **44** threadedly mates with the first head **28** in the bore **40**. Thus, the second shaft **42** extends along a direction oblique with respect to the first shaft **26**, which creates a stable triangular load bearing plane that allows the anchor-in-anchor fixation system **20** to withstand higher forces and prevent subsidence or migration with respect to single anchors.

As illustrated in FIG. 1D, the anchor-in-anchor fixation system **20** can join a pair of bone fragments **45a** and **45b** of a fractured bone **45** together, for instance when repairing the fractured bone **45**, and can further fix an implant to the bone **45**. The bone **45** can be a long bone, the first bone fragment **45a** can be a diaphysis, or shaft, of the long bone, and the second bone fragment **45b** can be a metaphysis of the long bone, though it is appreciated that the bone **45** can be any suitable bone as desired. As illustrated in FIG. 1C, the anchor-

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in-anchor fixation system **20** can be used to attach an implant to the bone **45**. In particular, one of the bone anchors, such as the first bone anchor **22**, can be driven through a bone plate **47** and into the bone **45**, and the second bone anchor **24** can be driven through the bore **40** of the first head **28** and into the bone **45**. As illustrated in FIG. 1D, the anchor-in-anchor fixation system **20** can be used to attach an implant in the medullary canal of the bone **45**. In particular, one of the bone anchors, such as the first bone anchor **22**, can be driven into the bone **45** and through an aperture of an intramedullary nail **49**, and the second bone anchor **24** can be driven through the bore **40** of the first head **28** and into the bone **45**.

SUMMARY

In accordance with one embodiment, a linkage is configured for use in an anchor-in-anchor system. The linkage includes a linkage body defining an open upper end, a lower end, and at least one side, the at least one side defining an internal void that extends between the upper and lower ends, the upper and lower ends spaced along a central axis of the linkage body. The lower end of the linkage body defines a first bore that is open to the internal void, the first bore extending along a central axis, the lower end threaded so as to purchase with complementary threads of a first head of a first bone anchor so as to attach the first bone anchor to the linkage. The linkage body includes an interior surface that defines a second bore that extends through the linkage body along a central axis that is oblique to the central axis of the first bore. The interior surface is threaded so as to purchase with complementary threads of a second head of a second bone anchor so as to attach the second bone anchor to the linkage.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing summary, as well as the following detailed description of the preferred embodiments of the application, will be better understood when read in conjunction with the appended drawings. For the purposes of illustrating the anchor-in-anchor system, there are shown in the drawings preferred embodiments. It should be understood, however, that the application is not limited to the precise arrangements and instrumentalities illustrated in the drawings, in which:

FIG. 1A is a side elevation view of an anchor-in-anchor system constructed in accordance with the prior art;

FIG. 1B is a sectional side elevation view of the anchor-in-anchor system illustrated in FIG. 1A;

FIG. 1C is a side elevation view of the anchor-in-anchor system illustrated in FIG. 1A, attached to a bone plate;

FIG. 1D is a side elevation view of the anchor-in-anchor system illustrated in FIG. 1A, attached to an intramedullary nail;

FIG. 2 is a perspective view of an anchor-in-anchor system constructed in accordance with one embodiment, including a first anchor, a second anchor, and a linkage that is attachable to the first and second anchors;

FIG. 3A is a top perspective view of the linkage illustrated in FIG. 2A;

FIG. 3B is a bottom perspective view of the linkage illustrated in FIG. 3A;

FIG. 3C is a top plan view of the linkage illustrated in FIG. 3A;

FIG. 3D is a side elevation view of the linkage illustrated in FIG. 3A;

FIG. 3E is a sectional side elevation view of the second anchor inserted into the linkage at a first angle;

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FIG. 3F is a sectional side elevation view similar to FIG. 3E, but showing the second anchor inserted into the linkage at a second angle different than the first angle;

FIG. 4A is a side elevation view of the anchor-in-anchor system illustrated in FIG. 2A, showing the second anchor extending from the linkage along a first direction so as to define a first angle with respect to the first anchor;

FIG. 4B is a perspective view of the anchor-in-anchor system illustrated in FIG. 4A, showing the second anchor extending from the linkage along a second direction so as to define a second angle with respect to the first anchor that is different than the first angle;

FIG. 5A is a perspective view of an anchor-in-anchor system similar to the anchor-in-anchor system illustrated in FIG. 2A, but showing the first anchor constructed in accordance with an alternative embodiment; and

FIG. 5B is a perspective view of the anchor-in-anchor system illustrated in FIG. 5A, but showing the second anchor extending from the linkage along a different direction.

DETAILED DESCRIPTION

Certain terminology is used in the following description for convenience only and is not limiting. The words “right,” “left,” “top,” and “bottom” designate in the drawings to which reference is made. The words “inwardly” and “outwardly” refer to directions toward and away from, respectively, the geometric center of the device and designated parts thereof. The words “anterior,” “posterior,” “superior,” “inferior,” and related words and/or phrases designate preferred positions and orientations in the human body to which reference is made and are not meant to be limiting. The terminology includes the above-listed words, derivatives thereof and words of similar import.

Referring to FIG. 2, an anchor-in-anchor fixation system 50 is illustrated as attached to an underlying structure or bone. The fixation system 50 is illustrated as a bone fixation system in accordance with one example embodiment that includes a first or primary bone fixation element or bone anchor 52, a second or auxiliary bone fixation element or bone anchor 54 that is configured to be coupled with respect to the first bone anchor 52, and a linkage 53 that is configured to attach to both the first and second bone anchors 52 and 54, thereby coupling the first and second bone anchors 52 and 54 with respect to each other. The bone fixation system 20 can be used to securely fasten auxiliary fixation devices such as external fixators, internal bone fixation devices, spinal fixation devices, and the like, to underlying bone. Unless otherwise indicated, the bone fixation system 20 and its components can be manufactured from any suitable biocompatible material known in the art including but not limited to titanium, titanium alloy such as TAN, stainless steel, reinforced plastics, allograft bone, and the like, unless otherwise indicated.

The first bone anchor 52 includes a first shaft 56 that extends longitudinally along, and is elongate along, a first central axis L1. The first shaft 56 defines a proximal or upper end 56a and a distal or lower end 56b that is spaced from the upper end 56a along the first central axis L1. The first bone anchor 52 can further include a first head 58 that is coupled to the upper end 56a. The first head 58 can be integral and monolithic with the first shaft 56, and can define external threads 59 (see FIG. 4A) so as to be threadedly and removably attachable to the linkage 53. The threads 59 of the first head 58 can be substantially cylindrical, or can be tapered inwardly, for instance either straight or curved, toward the first central axis L1 as the first head 58 extends along a distal direction from the first head 58 toward the first shaft 56.

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The first shaft 56 can define a plurality of external threads 60 that are disposed between the upper end 56a and the lower end 56b, and can extend from the upper end 56a to the lower end 56b, and are configured to threadedly engage an underlying bone as described above with reference to FIG. 1D. Thus, any portion of the first shaft 56 can be threaded as desired. For instance, a majority or substantial entirety of the first shaft 56 can be threaded. Alternatively, as will be described in more detail below, the first shaft 56 can be threaded at one or more discrete locations. It should thus be appreciated that the first bone anchor 52 can provide as a locking screw as illustrated, though it should be appreciated that the first bone anchor can alternatively be provided as a compression screw, a nail, rivet, or pin whose shaft is smooth or ribbed, as desired.

The first bone anchor 52 can further include a first drive member 55 that is carried by the first head 58 and is configured to mate with a driving instrument, such as a screw driver, that applies a torsional force to the first bone anchor 52 and drives the first bone anchor 52 into the bone. In accordance with the illustrated embodiment, the first drive member 55 can be configured as a socket of any suitable size and shape that extends into the first head 58 along a direction substantially parallel to the first central axis L1. The socket is configured to receive a driving end of the driving instrument. Alternatively, the first drive member 55 can be configured as a protrusion that is received by the driving instrument.

The second bone anchor 54 includes a second shaft 62 that extends longitudinally along, and is elongate along, a second central axis L2. The second shaft 62 that defines a proximal or upper end 62a and a distal or lower end 62b that is spaced from the upper end 62a along the second central axis L2. The second bone anchor 54 can further include a second head 64 that is coupled to the upper end 62a. The second head 64 can be integral and monolithic with the second shaft 62, and can define external threads 69 so as to be threadedly and removably attachable to the linkage 53. When first and second the second bone anchors 52 and 54 are attached to the linkage 53, the second central axis L2 is angularly offset with respect to the first central axis L1 so as to define an angle θ between the first central axis L1 and the second central axis L2. As will be described in more detail below, at least one of the first and second bone anchors 52 and 54 is attachable to the linkage 53 at different angular orientations such that the angle θ is adjustable.

The second shaft 62 can define external threads 61 that are disposed between the upper end 62a and the lower end 62b, and can extend from the upper end 62a to the lower end 62b, and are configured to engage the underlying bone in the manner described above with respect to FIG. 1D. Thus, any portion of the second shaft 62 can be threaded as desired. For instance, a majority or substantial entirety of the second shaft 62 can be threaded. Alternatively, as will be described in more detail below, the second shaft 62 can be threaded at one or more discrete locations. It should thus be appreciated that the second bone anchor 54 can provide as a locking screw as illustrated, though it should be appreciated that the first bone anchor can alternatively be provided as a compression screw, a nail, rivet, or pin whose shaft is smooth or ribbed, as desired.

The second bone anchor 54 can further include a second drive member 65 that is carried by the second head 64 and is configured to mate with a driving instrument, such as a screw driver, that applies a torsional force to the second bone anchor 54 and drives the second bone anchor 54 into the bone. In accordance with the illustrated embodiment, the second drive member 65 can be configured as a socket of any suitable size and shape that extends into the second head 64 along a direc-

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tion substantially parallel to the second central axis L2. The socket is configured to receive a driving end of the driving instrument. Alternatively, the second drive member 65 can be configured as a protrusion that is received by the driving instrument.

Referring now to FIGS. 2-3D, the linkage 53 is configured to operably couple the first bone anchor 52 and the second bone anchor 54, such that the first and second bone anchors 52 and 54 are fixed with respect to each other. In particular, the linkage 53 is configured to attach to the first and second heads 58 and 64, respectively. In accordance with the illustrated embodiment, the linkage 53 includes a linkage body 70 that extends along a central linkage axis 71, and defines a proximal or upper end 72 and a distal or lower end 74 that is spaced from the upper end 72 along the central linkage axis 71, and at least one side 76 that extends between the upper and lower ends 72 and 74 and defines an internal void 78 that extends through the linkage body 70 from the upper end 72 to the lower end 74.

The linkage body 70, and in particular the side 76, can be annular about the central linkage axis 71, or alternatively shaped and sized as desired. The at least one side 76 defines an inner surface 76a that defines the internal void 78, and an outer surface 76b that is opposite the inner surface 76a. The outer surface 76b can define any desired shape, and can be substantially circular about the central linkage axis 71 in cross-section in a plane that is normal to the central linkage axis 71. Further, the outer surface 76b can extend substantially parallel to the central linkage axis 71 from the between the upper end 72 and the lower end 74, or can extend toward the central linkage axis 71 as it extends down along a direction from the upper end 72 toward the lower end 74. Alternatively or additionally, the outer surface 76b can be curved as it extends between the upper end 72 and the lower end 74. For instance, the outer surface 76b can be convex.

The linkage 53 can include a pair of drive members 79 that are configured to mate with a driving instrument, such as a screw driver, that applies a torsional force to the linkage 53 and drives the linkage 53 into the threaded aperture of the implant or the bone. For instance, the drive members 79 can be configured as respective first and second opposed recesses 81 that extend into the linkage body 70, for instance into the upper end of the side 76. The recesses 81 can extend from the inner surface 76a through to the outer surface 76b. The recesses 81 can be radially opposite each other such that a straight line 67 that extends between the recesses 81 passes through the central linkage axis 71. The recesses 81 are configured to receive a driving end of the driving instrument. Alternatively, the recesses 81 can be configured as protrusions that are received by the driving instrument.

The linkage 53, and in particular the outer surface 76b, can define threads 80 that are configured to threadedly mate with threads of a complementary threaded aperture, for instance of an implant such as a bone fixation plate, or to purchase with the bone as the linkage 53 is driven into the bone. Alternatively, part or all of the outer surface 76b can be devoid of threads and substantially smooth.

The linkage 53 can further include at least one recess 82, such as a plurality of recesses 82 that extend into the linkage body 70 from the outer surface 76b toward the inner surface 76a. For instance, the recesses 82 can extend toward the central linkage axis 71, but do not extend through the inner surface 76a in accordance with one embodiment. The recesses 82 can divide the threaded outer surface 76b into a plurality of threaded segments 83 that can define cutting flutes

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that are configured to remove bone material when the linkage 53 contacts bone and is rotated about the central linkage axis 71.

The linkage 53 further defines first and second bores 84 and 86 that extend through the linkage body 70 and are configured to at least partially receive the first and second bone anchors 52 and 54, respectively. For instance, the first bore 84 can be defined by the lower end 74 of the linkage body 70 and can extend into the internal void 78. The lower end 74 of the linkage body 70 that defines the first bore 84 can define internal threads 87 that at least partially surround the first bore 84, such that the first bore 84 can be referred to as a threaded bore. The first bore 84 can extend along a central axis 88 that can be substantially parallel, and coincident, with the central linkage axis 71 of the linkage body 70. Thus, the first bore 84 can extend along the central linkage axis 71. The threads 87 are configured to mate with the external threads 59 of the first head 58 so as to threadedly attach the first head 58 to the linkage 53. The threads 87 can be substantially cylindrical, or can be tapered inwardly, either straight or curved, along a direction from the upper end 72 toward the lower end 74.

In accordance with the illustrated embodiment, the upper end 72 of the linkage body 70 is open, and defines a cross-sectional dimension, such as a diameter, that is greater than the outer cross-sectional dimension, such as diameter, of the first shaft 56. Similarly, the first bore 84 defines a cross-sectional dimension, such as a diameter, that is greater than the outer cross-sectional dimension, such as diameter, of the first shaft 56. Accordingly, the first shaft 56 can be driven substantially down along the central linkage axis 71 through the upper end 72 of the linkage body 70 and the first bore 84. The inner threads 87 of the first bore 84 can be sized substantially equal to the external threads 59 of the first head 58, such that once the first shaft 56 has been driven through the first bore 84, the threads 59 of the first head 58 mate with the threads 87 of the first bore 84 as the first bone anchor 52 is rotated along a first direction about the central axis L1, for instance clockwise, with respect to the linkage body 70. The threads 60 of the first shaft 56 can have substantially the same lead, and the same pitch as desired, as the threads 59 of the first head 58 to facilitate purchase between the first shaft 56 and the bone as the first head 58 threadedly engages the threads 85 of the first bore 84.

It should be appreciated that if desired, the first bone anchor 52 can be removed from the linkage 53. For instance, the first bone anchor 52 can be rotated along a second direction that is substantially opposite the first direction (e.g., counterclockwise) about the central axis L1, so as to disengage the threads 59 of the first head 58 from the threads 85 of the first bore 84, at which point the first bone anchor 52 can be driven up substantially along the central linkage axis 71 and through the upper end 72 of the linkage body 70.

With continuing reference to FIGS. 2-3D, the second bore 86 can extend through the side 76 from the outer surface 76b through the inner surface 76a so as to be open to the internal void 78. Thus, the side 76 can define an interior surface 77 that defines the second bore 86. The second bore 86 can extend along a central axis 90 that can be oriented along a direction that is angularly offset, for instance substantially perpendicular, with respect to the central linkage axis 71 of the linkage body 70 and the central axis 88 of the first bore 84. The central axis 90 intersects the central linkage axis 71 in accordance with one embodiment. The side 76 of the linkage body 70, and in particular the interior surface 77 that defines the second bore 86, can define internal threads 92 such that the second bore 86 can be referred to as a threaded bore. The threads 92 are configured to mate with the external threads 69 of the

second head **64** so as to threadedly attach the second head **64** to the linkage **53**. The threads **92** can be substantially cylindrical in shape as they extend along a radially outward direction away from the central linkage axis **71**, for instance from the central linkage axis **71** toward the second bore **86**, or can be tapered inwardly, either straight or curved, along the radially outward direction.

Referring now to FIGS. 2-3F, and as described above, the second bone anchor **54**, and in particular the second head **64**, is configured to threadedly purchase with the linkage **53**, for instance in the second bore **86**, such that the angle θ between the first and second central axes **L1** and **L2**, respectively, is adjustable within a range of angulation in the second bone anchor **54** in the second bore **86**. Accordingly, an angle α defined by the second axis **L2** and the central axis **90** of the second bore **86** is also adjustable within the range of angulation, such that the second axis **L2** can be angularly offset with respect to the central axis **90** at any angle as desired within the range of angulation. For instance, the second bone anchor **54** can be inserted into the second bore **86** such that the second axis **L2** is coaxial with the central axis **90** or at any angle relative to the central axis **90** within the range of angulation, which can be between and including 0 degrees and 15 degrees. The outer surface of the second head **64** can be round or substantially spherical as illustrated in FIGS. 3E-F, or substantially conically shaped or alternatively shaped as desired.

In accordance with the illustrated embodiment, the interior surface **77** includes a plurality of, for instance four, scalloped portions **94**, which can be unthreaded, that extend into the interior surface and interrupt the threads **92**. Accordingly, the scalloped portions separate the threads **92** into a corresponding plurality of columns **96** that are spaced from each other, such that ones of the scalloped portions are disposed between adjacent ones of the columns **96** along a circumferential direction about the central axis **90**. Each of the scalloped portions **94**, the columns **96** and the second head **64** can be shaped substantially as described in U.S. Patent Application Publication No. 2010/0312286, the disclosure of which is hereby incorporated by reference as if set forth herein. In accordance with the embodiment illustrated in FIGS. 3E-F, each of the columns **96** can have any suitable shape as desired. In accordance with the illustrated embodiment, each of the columns **96** has a complex shape including a first portion **96a** that tapers radially inward toward the central axis **90** from the outer surface **76b** toward the inner surface **76a** to a second portion **96b** that tapers radially outward from the first portion **96a** to the inner surface **76a** of the linkage body **70**. The first portions **96a** of the columns **96** are arranged along a first substantially conical shape centered on the central axis **90** of the second bore **86**, and the second portions **96b** of the columns **96** are arranged along a second substantially conical shape centered on the central axis **90** of the second bore **86**. The scalloped portions **94** between the columns **96** can be, for example, substantially cylindrically shaped and extend radially outward beyond the first and second conical shapes, thereby extending the range of angulation of the second bone anchor **54** when the second bone anchor **54** is inserted into the second bore **86**, for instance when the second shaft **62** is angularly aligned with the scalloped portions **94**.

In accordance with the illustrated embodiment, the second bore **86** can be defined by four columns **96**, spaced about the circumference of the second bore **86** substantially equidistant from one another with widths of the scalloped portions **94**, measured circumferentially about the central axis **90**, being substantially equal to one another. It should be appreciated, however, that the second bore **86** may include any number of

columns **96** arranged in any number of patterns as desired. Furthermore, it should be appreciated that the columns **96** can alternatively be spaced about the circumference of the second bore **86** by varying distances, and the columns **96** and scalloped portions **94** can have different circumferential widths as well.

The first portion **96a** of each of the columns **96** can extend radially inward from the outer surface **76b** toward the central axis **90** at an angle corresponding to the maximum angulation of the second bone anchor **54** relative to the central axis **90** of the second bore **86**. The first portion **96a** of each of the columns **96** can further include a corresponding plurality of columns of threads **92** that extend from the interior surface **77** into the second bore **86**. Each column **96** may include at least two individual threads **92**. However, it will be understood by those of skill in the art that the columns **96** may include any number of threads **92** as desired. The threads **92** are adapted and configured to engage the external threads **69** of the second head **64** and extend, for example, along paths which, if continued across the gaps defined by the scalloped portions **94**, would form a helical threading with a substantially constant pitch corresponding to the external threads **69** of the second head **64** of the second bone anchor **54**. Alternatively, the threads **92** on each of the columns **96** may be positioned along the first portion **96a** of the first column and arranged substantially symmetrically with respect to the threads **92** of the other columns **96**.

The second portion **96b** of each of the columns **96** extends radially outward with respect to the first portion **96a**, for instance from the first portion **96a**, toward the outer face surface **76b**, for instance to the outer surface **76b**, such that the substantially conical portion formed by the second portions **96b** of each of the columns **96** is adapted and configured to accommodate the upper end **62a** of the second shaft **62** at varying angles within the range of angulation. The spherical shape of the second head **64** permits the external threads **69** to engage the threads **92** of the second bore **86** whether inserted co-axially with the central axis **90** of the second bore **86** as shown in FIG. 3E, or offset from the central axis **90** within the range of angulation, as shown in FIG. 3F.

Referring now to FIGS. 2-3D, the linkage **53** can further include an aperture **98** that provides access to the second bore **86**, such that a driver instrument can partially extend through the aperture **98** and engage the drive member **65** of the second bone anchor **54** such that the drive member can apply a torsional force that causes the second bone anchor **56** to drive into bone and further cause the second bone anchor **56** to threadedly attach to the second bore **86**. Thus, the linkage **53** can define a straight line that passes through both the aperture **98** and the drive member **65** of the second bone anchor **54**, and thus through the second bore **86**. In accordance with the illustrated embodiment, the aperture **98** extends radially through the linkage body **70**, for instance through the side **76** from the outer surface **76b** through the inner surface **76a**, and further extends down into the linkage body **70** from the upper end **72** toward, but not to, the lower end **74**. The aperture **98** is thus open to the upper end **72** of the linkage body **70**, and defines slot that can be elongate along a direction substantially parallel to the central linkage axis **71**. The aperture **98** can be radially opposite the second bore **86** such that the straight line that passes through both the aperture **98** and the second bore **86** also passes through the central linkage axis **71**. The aperture **98** can further have a circumferential width that can be substantially equal to that of the driver instrument. Accordingly, the driver instrument can angulate within the aperture **98** about a pivot axis that is substantially perpendicular to both the central linkage axis **71** of the linkage body **70**

and the central axis **90** of the second bore **86**. Thus, the drive instrument and the second bone anchor **54** can angulate along a plane defined by the central linkage axis **71** and the central axis **90**, which allows the drive instrument to engage the second drive member **65** when the central axis **L2** of the second bone anchor **54** is oriented at any angle within the range of angulation defined by the second bore **86**.

The aperture **98** defines a cross-sectional dimension, such as a circumferential cross-sectional dimension, that is greater than the outer cross-sectional dimension, such as diameter, of the second shaft **62**. Similarly, the second bore **86** defines a cross-sectional dimension, such as a diameter, that is greater than the outer cross-sectional dimension, such as diameter, of the second shaft **62**. Accordingly, the second shaft **62** can be driven substantially down along the central axis **90** through the aperture **98** and further through the second bore **86**. The inner threads **92** of the second bore **86** can be sized substantially equal to the external threads **69** of the second head **64**, such that once the second shaft **62** has been driven through the second bore **86**, the threads **69** of the second head **64** mate with the threads **92** of the second bore **86** as the second bone anchor **54** is rotated along a first direction, for instance clockwise, with respect to the linkage body **70**. The threads **61** of the second shaft **62** can have substantially the same pitch as the threads **69** of the second head **64** to facilitate purchase between the second shaft **62** and the bone as the second head **64** threadedly engages the threads **92** of the second bore **86** along any direction within the range of angulation permitted by the second bore **86**. It should be appreciated that while the aperture **98** is illustrated as open to the upper end **72** of the linkage body **70**, the aperture **98** could alternatively be enclosed by the linkage body **70** as desired.

Thus, the second head **64** can mate with the threads **80** of the second bore **86** when the second central axis **L2** of the second shaft **62** is oriented oblique to the first central axis **L1** of the first shaft **56** so as to define an adjustable angle θ with respect to the first central axis **L1**, within the range of angles permitted by the second bore **86**, as illustrated in FIGS. 4A-5B. For instance, the second bone anchor **54** can mate with the linkage body **70** in the second bore **86** such that the second central axis **L2** defines a first angle $\theta 1$ with respect to the first central axis **L1** as illustrated in FIGS. 4A and 5A, or can mate with the linkage body **70** in the second bore **86** such that the second central axis **L2** defines a second angle $\theta 2$ with respect to the second central axis **L2** that is different than the first angle $\theta 1$ as illustrated in FIGS. 4B and 5B. For instance, the second central axis **L2** is substantially coincident with the central axis **90** and substantially perpendicular to the first central axis **L1** when the second bone anchor **56** is attached to the linkage body **70** within the second bore **86** at an angle of zero degrees, and is oriented oblique (for instance less than 90 degrees) with respect to the first central axis **L1** when the second bone anchor **56** is attached to the linkage body **70** within the second bore **86** at an angle of greater than zero degrees. As described above, with respect to FIGS. 1C-D, the first bone anchor **52** can be driven into bone and through an aperture of an implant, such as a bone plate or intramedullary nail, and the second bone anchor **54** can be driven into bone at an adjustable angle with respect to the first bone anchor **52**. Furthermore, referring to FIGS. 4A-4B, the first shaft **56** can be threaded substantially along its length, or as illustrated in FIGS. 5A-B can be configured as a lag screw such that the first shaft **56** is threaded only at the distal end **52b**, and is smooth between the threads at the distal end **52b** and the proximal end **52a**.

It should be appreciated that if desired, the second bone anchor **54** can be removed from the linkage **53**. For instance,

the second bone anchor **54** can be rotated along a second direction that is substantially opposite the first direction (e.g., counterclockwise), so as to disengage the threads **69** of the second head **64** from the threads **92** of the second bore **86**, at which point the second bone anchor **54** can be driven up substantially along the central axis **90** of the second bore **86**.

While the linkage **53** is illustrated as separate from the first and second bone anchors **52** and **54** and selectively removably attachable to the first and second bone anchors **52** and **54** in the manner described above, it should be appreciated that the linkage **53** can be integral and monolithic with the first bone anchor **52**, for instance the first shaft **56**, such that the linkage **53** defines the head of the first bone anchor **52** in the manner described above with respect to FIGS. 1A-B, and allows the second bone anchor **54** to be threadedly attached to the linkage **53** at variable angles in the manner described above. Thus, the bore **40** of the first bone anchor **22** illustrated in FIGS. 1A-B can be constructed as described with respect to the second bore **86**. Furthermore, while the second bore **86** has been described as being defined by the scalloped portions **94** and the columns **96** that permit the head of the second bone anchor **54** to mate with the second bore **86** within a range of angles, the first bore **84** can alternatively or additionally be defined by the scalloped portions **94** and columns **96** so as to allow the first bone anchor **52** to attach to the lower end **74** of the linkage body **70** at a range of angles with respect to the central linkage axis **71** as described above. Alternatively, the first bore **84** can be configured to only mate with the first head when the first central axis **L1** is coincident with the central linkage axis **71** of the linkage body **70**.

Although the invention has been described with reference to preferred embodiments or preferred methods, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. For instance, it should be appreciated that the structures and features of the various bone fixation assemblies and systems described herein and their components can be incorporated into any of the other bone fixation assemblies and systems described herein and their components, unless otherwise indicated. Furthermore, although the invention has been described herein with reference to particular structure, methods, and embodiments, the invention is not intended to be limited to the particulars disclosed herein, as the invention extends to all structures, methods and uses that are within the scope of the present invention, along with kits having one or more fixation systems, assemblies, or components thereof as described herein. Those skilled in the relevant art, having the benefit of the teachings of this specification, may effect numerous modifications to the invention as described herein, and changes may be made without departing from the scope and spirit of the invention, for instance as recited in the appended claims.

What is claimed:

1. A linkage configured for use in an anchor-in-anchor system, the linkage comprising:
 - a linkage body defining an open upper end, a lower end, and at least one side having a threaded outer surface and an inner surface opposite the threaded outer surface, wherein the inner surface defines an internal void that extends between the upper and lower ends, the upper and lower ends spaced from each other along a central linkage axis of the linkage body;
 - wherein 1) the lower end of the linkage body defines a first bore that is open to the internal void, the first bore extending along a central axis, the lower end internally threaded so as to purchase with complementary threads of a first head of a first bone anchor and attach the first

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bone anchor to the linkage, and 2) the linkage body includes an interior surface that defines a second bore that extends through the linkage body along a central axis that is oblique to the central linkage axis, the interior surface threaded so as to purchase with complementary threads of a second head of a second bone anchor so as to attach the second bone anchor to the linkage.

2. The linkage as recited in claim 1, wherein the central axis of the first bore is substantially coincident with the central linkage axis.

3. The linkage as recited in claim 1, wherein the at least one side is annular.

4. The linkage as recited in claim 1, wherein the outer surface defines a circle about the central linkage axis in a plane that is normal to the central linkage axis.

5. The linkage as recited in claim 1, wherein the outer surface is tapered toward the central linkage axis as the at least one side extends along a direction from the upper end toward the lower end.

6. The linkage as recited in claim 1, wherein the second head is configured to mate with the interior surface at any angle within a range of angles relative to the central axis of the second bore.

7. The linkage as recited in claim 6, further comprising a plurality of scalloped portions that separate the interior surface into a corresponding plurality of threaded columns.

8. The linkage as recited in claim 7, wherein each of the scalloped portions extends radially outward with respect to the central axis of the second bore.

9. The linkage as recited in claim 8, wherein each of the scalloped portions is unthreaded.

10. The linkage as recited in claim 6, further comprising an aperture that extends through the linkage body from the inner surface to the outer surface, the aperture further extending into the linkage body along a direction from the upper end to the lower end at a location radially opposite the second bore, such that a straight line passes through both the aperture and the second bore.

11. The linkage as recited in claim 1, wherein the linkage body defines a plurality of recesses that extend from the outer surface toward the inner surface.

12. The linkage as recited in claim 11, wherein the recesses do not extend through the inner surface.

13. The linkage as recited in claim 11, wherein the recesses divide the outer surface into a plurality of threaded cutting flutes.

14. The linkage as recited in claim 1, wherein the outer surface defines a plurality of cutting flutes.

15. An anchor-in-anchor system comprising:

a linkage configured for use in an anchor-in-anchor system, the linkage including:

a linkage body defining an open upper end, a lower end, and at least one side having a threaded outer surface and an inner surface opposite the threaded outer sur-

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face, wherein the inner surface defines an internal void that extends between the upper and lower ends, the upper and lower ends spaced from each other along a central linkage axis of the linkage body;

wherein 1) the lower end of the linkage body defines a first bore that is open to the internal void, the first bore extending along a central axis, the lower end internally threaded, and 2) the linkage body includes a threaded interior surface that defines a second bore that extends through the linkage body along a central axis that is oblique to the central linkage axis;

a first bone anchor including a first threaded head and a first shaft that extends from the first threaded head along a first central axis, wherein the first threaded head is configured to threadedly attach to the linkage in the first bore; and

a second bone anchor including a second threaded head and a second shaft that extends from the second threaded head along a second central axis, wherein the second threaded head is configured to threadedly attach to the threaded interior surface,

wherein the first central axis is coincident with the central axis of the first bore when the first head is attached to the lower end of the linkage, and the second central axis is oblique with respect to the first central axis when the second head is attached to the interior surface.

16. The anchor-in-anchor system as recited in claim 15, wherein the first head is monolithic with the first shaft, and the second head is monolithic with the second shaft.

17. The anchor-in-anchor system as recited in claim 15, wherein the second head is attachable to the interior surface at a range of angles such that the second central axis defines an adjustable angle with respect to the first central axis.

18. An anchor-in-anchor system comprising:

the linkage recited in claim 1;

the first bone anchor recited in claim 1, further including a first shaft that extends from the first head along a first central axis; and

the second bone anchor recited in claim 1, further including a second shaft that extends from the second head along a second central axis;

wherein the first central axis is coincident with the central axis of the first bore when the first head is threadedly attached to the lower end of the linkage, and the second central axis is oblique with respect to the first central axis when the second head is attached to the interior surface.

19. The anchor-in-anchor system as recited in claim 18, wherein the first head is monolithic with the first shaft, and the second head is monolithic with the second shaft.

20. The anchor-in-anchor system as recited in claim 19, wherein the second head is attachable to the interior surface at a range of angles such that the second central axis defines an adjustable angle with respect to the first central axis.

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